

NATIONAL BUREAU OF STANDARDS REPORT

5320

**SKELETON TABLES
FOR
MANUAL ON EXPERIMENTAL STATISTICS
FOR ORDNANCE ENGINEERS**

**A Report to
Office of Ordnance Research
Department of the Army**



**U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS**

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Skeleton Tables for

Manual on Experimental Statistics
for Ordnance Engineers

Prepared by

Statistical Engineering Laboratory

A Report to

Office of Ordnance Research
Department of the Army

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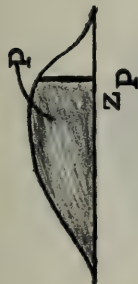
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Table Ia

Cumulative Normal Distribution

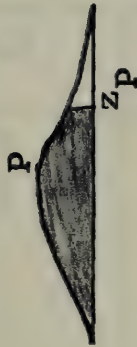


Values of P corresponding to z_p for the normal curve
 z is the standard normal variable.

z_p	0	.1	.2	.3	.4	.5	.6	.7	.8	.9
-3	.0013	.0010	.0007	.0005	.0003	.0002	.0002	.0001	.0001	.0000
-2	.0228	.0179	.0139	.0107	.0082	.0062	.0047	.0035	.0026	.0019
-1	.1587	.1357	.1151	.0968	.0808	.0668	.0548	.0446	.0359	.0287
-0	.5000	.4602	.4207	.3821	.3446	.3085	.2743	.2420	.2119	.1841
+0	.5000	.5398	.5793	.6179	.6554	.6915	.7257	.7580	.7881	.8159
1	.8413	.8643	.8849	.9032	.9192	.9332	.9452	.9554	.9641	.9713
2	.9772	.9821	.9861	.9893	.9918	.9938	.9953	.9965	.9974	.9981
3	.9987	.9990	.9993	.9995	.9997	.9998	.9998	.9999	.9999	1.0000

Table Ib

Cumulative Normal Distribution



Values of z_p Corresponding to P for the normal curve.
 z is the standard normal variable

P	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
.00	-	-2.33	-2.05	-1.88	-1.75	-1.64	-1.55	-1.48	-1.41	-1.34
.10	-1.28	-1.23	-1.18	-1.13	-1.08	-1.04	-0.99	-0.95	-0.92	-0.88
.20	-0.84	-0.81	-0.77	-0.74	-0.71	-0.67	-0.64	-0.61	-0.58	-0.55
.30	-0.52	-0.50	-0.47	-0.44	-0.41	-0.39	-0.36	-0.33	-0.31	-0.28
.40	-0.25	-0.23	-0.20	-0.18	-0.15	-0.13	-0.10	-0.08	-0.05	-0.03
.50	0.00	0.03	0.05	0.08	0.10	0.13	0.15	0.18	0.20	0.23
.60	0.25	0.28	0.31	0.33	0.36	0.39	0.41	0.44	0.47	0.50
.70	0.52	0.55	0.58	0.61	0.64	0.67	0.71	0.74	0.77	0.81
.80	0.84	0.88	0.92	0.95	0.99	1.04	1.08	1.13	1.18	1.23
.90	1.28	1.34	1.41	1.48	1.55	1.64	1.75	1.88	2.05	2.33

Special values

P	.001	.005	.010	.025	.050	.100
z_p	-3.090	-2.576	-2.326	-1.960	-1.645	-1.282
P	.999	.995	.990	.975	.950	.900
z_p	3.090	2.576	2.326	1.960	1.645	1.282

TABLE II

Percentiles of the t Distribution

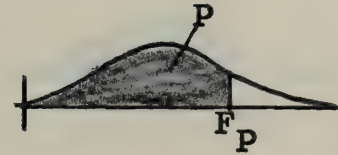


d.f.	$t_{.90}$	$t_{.95}$	$t_{.975}$	$t_{.99}$	$t_{.995}$
1	3.078	6.314	12.706	31.821	63.657
2					
⋮					
9			2.262	2.821	
⋮					
19		1.729	2.093		
⋮					
120					
∞	1.282	1.645	1.960	2.326	2.576

Use d.f. 1(1)30, 40, 60, 120, ∞. Values taken from Table A-5 Dixon and Massey "Introduction to Statistical Analysis," Second Edition, McGraw-Hill (1957).

TABLE III

Percentiles of the F Distribution



$$F_{.95}(n_1, n_2)$$

n_1 = degrees of freedom for numerator

n_2 = degrees of
freedom for denomi-
nator.

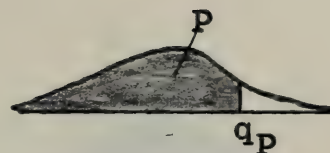
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Reproduce from Dixon and Massey, Table A-7a, Second Edition, McGraw-Hill (1957).

Reproduce also $F_{.99}(n_1, n_2)$. This is Table A-7b of the above reference.

TABLE IV

Percentiles of q (Studentized Range)



$q = w/s$. w is the range of t observations, and v is the number of degrees of freedom associated with the standard deviation s .

$q_{.95}$

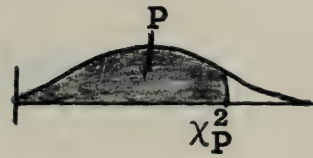
$v \backslash t$	2(1)20
1 (1) 20	

$q_{.99}$

$v \backslash t$	2(1)20
1 (1) 20	

Values for above tables taken from Table A-18, Dixon and Massey, Second Edition (1957).

Percentiles of the χ^2 Distribution



d.f.	$\chi^2_{.90}$	$\chi^2_{.95}$	$\chi^2_{.975}$	$\chi^2_{.99}$	$\chi^2_{.995}$

$$\chi_p^2 \approx (z_p + \sqrt{2(d.f.) - 1})^2 / 2$$

d.f. = 1(1) 16, 18, 20, 24, 30, 40, 60, 120

Values taken from Table A-6a, Dixon and Massey, McGraw-Hill Second Edition (1957).

TABLE VI

Confidence Belts for Proportions

(Change labels,	Ordinate label - P Abcissae label - p)
1st chart	Confidence coefficient .90
2nd chart	Confidence coefficient .95
3rd chart	Confidence coefficient .99

Charts 1,2,3 are reproduced from Dixon and Massey, p. 414, 415, 416, Second Edition, McGraw-Hill (1957).

TABLE VII

Confidence Belts for the Correlation Coefficient
(confidence coefficient .95)

Reproduced from Table A-27, Dixon and Massey, Second Edition,
McGraw-Hill (1957).

TABLE VIII

Weighting Coefficients for Probit Analysis

Y	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1	0.001	0.001	0.001	0.002	0.002	0.003	0.005	0.006	0.008	0.011
2	0.015	0.019	0.025	0.031	0.040	0.050	0.062	0.076	0.092	0.110
3	0.131	0.154	0.180	0.208	0.238	0.269	0.302	0.336	0.370	0.405
4	0.439	0.471	0.503	0.532	0.558	0.581	0.601	0.616	0.627	0.634
5	0.637	0.634	0.627	0.616	0.601	0.581	0.558	0.532	0.503	0.471
6	0.439	0.405	0.370	0.336	0.302	0.269	0.238	0.208	0.180	0.154
7	0.131	0.110	0.092	0.076	0.062	0.050	0.040	0.031	0.025	0.019
8	0.015	0.011	0.008	0.006	0.005	0.003	0.002	0.002	0.001	0.001

Values obtained from page 32, Finney, Cambridge University Press (1952).

TABLE IX

Maximum and Minimum Working Probits and Range

Expected probit Y	Minimum working probit y_0	Range 1/z	Maximum working probit y_{100}	Expected probit Y
1.1	0.8579	5034	9.1421	8.9
1.2	0.9522	3425	9.0478	8.8
1.3	1.0462	2354	8.9538	8.7
1.4	1.1400	1634	8.8600	8.6
1.5	1.2334	1146	8.7666	8.5
1.6	1.3266	811.5	8.6734	8.4
1.7	1.4194	580.5	8.5806	8.3
1.8	1.5118	419.4	8.4882	8.2
1.9	1.6038	306.1	8.3962	8.1
2.0	1.6954	225.6	8.3046	8.0
2.1	1.7866	168.00	8.2134	7.9
2.2	1.8772	126.34	8.1228	7.8
2.3	1.9673	95.96	8.0327	7.7
2.4	2.0568	73.62	7.9432	7.6
2.5	2.1457	57.05	7.8543	7.5
2.6	2.2339	44.654	7.7661	7.4
2.7	2.3214	35.302	7.6786	7.3
2.8	2.4081	28.189	7.5919	7.2
2.9	2.4938	22.736	7.5062	7.1
3.0	2.5786	18.5216	7.4214	7.0
3.1	2.6624	15.2402	7.3376	6.9
3.2	2.7449	12.6662	7.2551	6.8
3.3	2.8261	10.6327	7.1739	6.7
3.4	2.9060	9.0154	7.0940	6.6
3.5	2.9842	7.7210	7.0158	6.5
3.6	3.0606	6.6788	6.9394	6.4
3.7	3.1351	5.8354	6.8649	6.3
3.8	3.2074	5.1497	6.7926	6.2
3.9	3.2773	4.5903	6.7227	6.1
4.0	3.3443	4.1327	6.6557	6.0
4.1	3.4083	3.7582	6.5917	5.9
4.2	3.4687	3.4519	6.5313	5.8
4.3	3.5251	3.2025	6.4749	5.7
4.4	3.5770	3.0010	6.4230	5.6
4.5	3.6236	2.8404	6.3764	5.5
4.6	3.6643	2.7154	6.3357	5.4
4.7	3.6982	2.6220	6.3018	5.3
4.8	3.7241	2.5573	6.2759	5.2
4.9	3.7407	2.5192	6.2593	5.1
5.0	3.7467	2.5066	6.2533	5.0

TABLE X

Tolerance Factors for Normal Distributions

Factors K such that the probability is γ that at least a proportion P of the distribution will be included between $\bar{X} + Ks$, where \bar{X} and s are estimates of the mean and standard deviation computed from a sample of n .

Use format as pp. 102-107, "Techniques of Statistical Analysis", Eisenhart, Hastay and Wallis, McGraw-Hill (1947).
Abridge, using $n = 2(1)20, 25, 30(10)100, 100(100)600,$
 $800, 1000, \infty$.

TABLE XI

Criteria for Rejection of Outlying Observations

Statistic	Number of observations n	Critical values						
		$\alpha =$.30	$\alpha =$.20	$\alpha =$.10	$\alpha =$.05	$\alpha' =$.02	$\alpha' =$.01	$\alpha' =$.005

Reproduced from Table A-8e, Dixon and Massey, McGraw-Hill,
Second Edition (1957).

TABLE XII

Percentiles of $T(n)$ for the "Wilcoxon Signed-ranks Test"

n	$T_{.025}(n)$	$T_{.01}(n)$	$T_{.005}(n)$
6	0	-	-
7	2	0	-
8	4	2	0
9	6	3	2
10	8	5	3
11	11	7	5
12	14	10	7
13	17	13	10
14	21	16	13
15	25	20	16
16	30	24	20
17	35	28	23
18	40	33	28
19	46	38	32
20	52	43	38
21	59	49	43
22	66	56	49
23	73	62	55
24	81	69	61
25	89	77	68

Adapted from Table II, F. Wilcoxon, 1949, "Some rapid approximate statistical procedures", New York:American Cyanamid Company, p. 14.

(See also, Table G, p. 254, Siegel, "Non-parametric Statistics", McGraw-Hill (1956)).

For large n ,

$$T_p(n) = \frac{n(n+1)}{4} - z_{1-p} \sqrt{\frac{n(n+1)(2n+1)}{24}} \quad \text{approximately}$$

where z is given in Table I.

TABLE XIII

Probabilities Associated with the Mann-Whitney Test

Probabilities associated with values as small as U.

Reproduce tables of Mann and Whitney from Annals of Mathematical Statistics Volume 18, (1947), pp. 52-54.

(Same tables are in Siegel, McGraw-Hill, 1956, Table J).

Eliminate last two columns of last table. Put note above each table:

" n_1 is the smaller of n_A, n_B ,

n_2 is the larger of n_A, n_B ."

TABLE XIV

Percentiles of $U(n_1, n_2)$ for the "Mann Whitney" Test

- a) $U_{.001}(n_1, n_2)$ Reproduce Table K_1 p. 274 of *.
- b) $U_{.01}(n_1, n_2)$ Reproduce Table K_2 p. 275 of *.
- c) $U_{.025}(n_1, n_2)$ Reproduce Table K_3 p. 276 of *.
- d) $U_{.05}(n_1, n_2)$ Reproduce Table K_4 p. 277 of *.

Put note above each table: " n_2, n_1 are the larger and smaller respectively of n_A, n_B ."

*) Siegel, McGraw-Hill, 1956.

NOTE: for $n > 20$,

$$U_{\alpha/2} = \frac{n_A n_B}{2} - z_{1-\alpha/2} \sqrt{\frac{n_A n_B (n_A + n_B + 1)}{12}}$$

approximately where z is given in Table I.

TABLE XV

Tables for Distribution-free Tolerance Limits (Two-sided)

Values (r,s) such that we may assert with confidence at least γ that 100p percent of a population lies between the rth smallest and the sth largest of a random sample of n from that population (no assumption of normality required).

n \ P	$\gamma = 0.75$			$\gamma = 0.90$			$\gamma = 0.95$			$\gamma = 0.99$		
	.75	.90	.99	.75	.90	.99	.75	.90	.99	.75	.90	.99
50	5,5	2,1	-	5,4	1,1	-	4,4	1,1	-	3,3	-	-
55	6,6	2,2	1,1	5,5	2,1	-	5,4	1,1	-	4,3	-	-
60	7,6	2,2	1,1	6,5	2,1	-	5,5	1,1	-	4,4	-	-
65	7,7	3,2	1,1	6,6	2,2	-	6,5	2,1	-	5,4	-	-
70	8,7	3,2	1,1	7,6	2,2	-	6,6	2,1	-	5,5	-	-
75	8,8	3,3	1,1	7,7	2,2	-	7,6	2,1	-	5,5	-	-
80	9,8	3,3	2,2	8,7	3,2	-	7,7	2,2	-	6,5	-	-
85	10,9	4,3	2,2	8,8	3,2	1,1	8,7	2,2	-	6,6	-	-
90	10,10	4,3	2,2	9,8	3,2	1,1	8,8	3,2	-	7,6	-	-
95	11,10	4,3	2,2	9,9	3,3	1,1	9,8	3,2	-	7,7	-	-
100	11,11	4,4	2,2	10,10	3,3	1,1	9,9	3,2	-	8,7	-	-
110	12,12	5,4	2,2	11,11	4,3	2,1	10,10	3,3	1,1	9,8	-	-
120	14,13	5,5	2,2	12,12	4,4	2,1	11,11	4,3	1,1	10,9	-	-
130	15,14	6,5	3,2	13,13	5,4	2,1	13,12	4,4	2,1	11,10	-	-
140	16,15	6,6	3,2	14,14	5,5	2,2	14,13	4,4	2,1	12,11	-	-
150	17,17	6,6	3,3	16,15	5,5	2,2	15,14	5,4	2,1	13,13	-	-
170	20,19	7,7	4,3	18,17	6,6	3,2	17,16	6,5	2,2	15,15	-	-
200	23,23	9,8	4,4	21,21	8,7	3,3	20,20	7,6	3,2	18,18	-	-
300	35,35	13,13	6,6	33,32	12,11	5,5	32,31	11,11	5,4	29,29	-	-
400	47,47	18,18	9,8	45,44	16,16	8,7	43,43	15,15	7,6	40,40	-	-
500	59,59	23,22	11,11	57,56	21,20	10,9	55,54	20,19	9,8	52,51	-	-
600	72,71	28,27	13,13	68,68	26,25	12,11	67,66	24,24	11,10	63,63	-	-
700	84,83	33,32	16,15	80,80	30,30	14,14	78,78	29,28	13,13	75,74	-	-
800	96,96	37,37	18,18	92,92	35,34	16,16	90,90	33,33	15,15	86,86	-	-
900	108,108	42,42	21,20	104,104	40,39	19,18	102,102	38,37	18,17	98,97	-	-
1000	121,120	47,47	23,22	117,116	44,44	21,20	114,114	43,42	20,19	110,109	-	-

TABLE XVI

Tables for Distribution-free Tolerance Limits (One-sided)

Largest values of m such that we may assert with confidence at least γ that 100P percent of a population lies below the m th largest (or above the m th smallest) of a random sample of n from that population (no assumption of normality required).

$\frac{p}{n}$	$\gamma = 0.75$				$\gamma = 0.90$				$\gamma = 0.95$				$\gamma = 0.99$			
	.75	.90	.95	.99	.75	.90	.95	.99	.75	.90	.95	.99	.75	.90	.95	.99
50	10	3	1	-	9	2	1	-	8	2	-	-	6	1	-	-
55	12	4	2	-	10	3	1	-	9	2	-	-	7	1	-	-
60	13	4	2	-	11	3	1	-	10	2	1	-	8	1	-	-
65	14	5	2	-	12	4	1	-	11	3	1	-	9	2	-	-
70	15	5	2	-	13	4	1	-	12	3	1	-	10	2	-	-
75	16	6	2	-	14	4	1	-	13	3	1	-	10	2	-	-
80	17	6	3	-	15	5	1	-	14	4	1	-	11	2	-	-
85	19	7	3	-	16	5	2	-	15	4	1	-	12	2	-	-
90	20	7	3	-	17	5	2	-	16	5	1	-	13	3	-	-
95	21	7	3	-	18	6	2	-	17	5	2	-	14	3	1	-
100	22	8	3	-	20	6	2	-	18	5	2	-	15	4	1	-
110	24	9	4	-	22	7	3	-	20	6	2	-	17	4	1	-
120	27	10	4	-	24	8	3	-	22	7	2	-	19	5	1	-
130	29	11	5	-	26	9	3	-	25	8	3	-	21	6	2	-
140	31	12	5	1	28	10	4	-	27	8	3	-	23	6	2	-
150	34	12	6	1	31	10	4	-	29	9	3	-	26	7	2	-
170	39	14	7	1	35	12	5	-	33	11	4	-	30	9	3	-
200	46	17	8	1	42	15	6	-	40	13	5	-	36	11	4	-
300	70	26	12	2	65	23	10	1	63	22	9	1	58	19	7	-
400	94	36	17	3	89	32	15	2	86	30	13	1	80	27	11	-
500	118	45	22	3	113	41	19	2	109	39	17	2	103	35	14	1
600	143	55	26	4	136	51	23	3	133	48	21	2	126	44	18	1
700	167	65	31	5	160	60	28	4	156	57	26	3	149	52	22	2
800	192	74	36	6	184	69	32	5	180	66	30	4	172	61	26	2
900	216	84	41	7	208	79	37	5	204	75	35	4	195	70	30	3
1000	241	94	45	8	233	88	41	6	228	85	39	5	219	79	35	3

TABLE XVII

Confidence Associated with a Tolerance Limit Statement

Confidence γ with which we may assert that 100P percent of the population lies between the largest and smallest of a random sample of n from that population (continuous distribution assumed).

n	P=.75	P=.90	P=.95	P=.99	n	P=.75	P=.90	P=.95	P=.99
3	.16	.03	.01	.00	17	.95	.52	.21	.01
4	.26	.05	.01	.00	18	.96	.55	.23	.01
5	.37	.08	.02	.00	19	.97	.58	.25	.02
6	.47	.11	.03	.00	20	.98	.61	.26	.02
7	.56	.15	.04	.00	25	.99	.73	.36	.03
8	.63	.19	.06	.00	30	1.00-	.82	.45	.04
9	.70	.23	.07	.00	40		.92	.60	.06
10	.76	.26	.09	.00	50		.97	.72	.09
11	.80	.30	.10	.01	60		.99	.81	.12
12	.84	.34	.12	.01	70		.99	.87	.16
13	.87	.38	.14	.01	80		1.00-	.91	.19
14	.90	.42	.15	.01	90			.94	.23
15	.92	.45	.17	.01	100			.96	.26
16	.94	.49	.19	.01					

Table 1. Summary of the study area.

Table 2. Summary of the study area.

Table 3. Summary of the study area.

Table 4. Summary of the study area.

Table 5. Summary of the study area.

Table 6. Summary of the study area.

Table 7. Summary of the study area.

Table 8. Summary of the study area.

Table 9. Summary of the study area.

Table 10. Summary of the study area.

TABLE XVIIIa

Table of Required Sample Sizes

Sample size required for detecting, with probability $1-\beta$, whether the average m of a new product differs from the standard m_0 (or whether two product averages m_A and m_B differ).

$$d = \frac{m-m_0}{\sigma} \quad (\text{or } d = \frac{m_A-m_B}{\sqrt{\sigma_A^2+\sigma_B^2}} \text{ if we are comparing two products}).$$

The standard deviations are assumed to be known.

$$\alpha = .01$$

$d \backslash 1-\beta$.50	.60	.70	.80	.90	.95	.99
.1	664	801	962	1168	1488	1782	2404
.2	166	201	241	292	372	446	601
.4	42	51	61	73	93	112	151
.6	19	23	27	33	42	50	67
.8	11	13	16	19	24	28	38
1.0	7	9	10	12	15	18	25
1.2	5	6	7	9	11	13	17
1.4	4	5	5	6	8	10	13
1.6	3	4	4	5	6	7	10
1.8	3	3	3	4	5	6	8
2.0	2	3	3	3	4	5	7
3.0	1	1	2	2	2	2	3

If we must estimate σ from our sample, and use Student's t then we should add 4 to the tabulated values to obtain the approximate required sample size. (If we are comparing two product averages, add 2 to the tabulated values, For this case, we must have $\sigma_A = \sigma_B$).

TABLE XVIIIa (Continued)

$$\alpha = .05$$

$\begin{array}{c} 1-\beta \\ d \end{array}$.50	.60	.70	.80	.90	.95	.99
.1	385	490	618	785	1051	1300	1838
.2	97	123	155	197	263	325	460
.4	25	31	39	50	66	82	115
.6	11	14	18	22	30	37	52
.8	7	8	10	13	17	21	29
1.0	4	5	7	8	11	13	19
1.2	3	4	5	6	8	10	13
1.4	2	3	4	5	6	7	10
1.6	2	2	3	4	5	6	8
1.8	2	2	2	3	4	5	6
2.0	1	2	2	2	3	4	5
3.0	1	1	1	1	2	2	3

If we must estimate σ from our sample and use Student's t , then we should add 2 to the tabulated values to obtain the approximate required sample size. (If we are comparing two produce averages, add 1 to the tabulated values).

1890

No.	Date	Particulars	Debit	Credit	Balance	Total
1	Jan 1	Balance				
2	Jan 2	Jan 2				
3	Jan 3	Jan 3				
4	Jan 4	Jan 4				
5	Jan 5	Jan 5				
6	Jan 6	Jan 6				
7	Jan 7	Jan 7				
8	Jan 8	Jan 8				
9	Jan 9	Jan 9				
10	Jan 10	Jan 10				
11	Jan 11	Jan 11				
12	Jan 12	Jan 12				
13	Jan 13	Jan 13				
14	Jan 14	Jan 14				
15	Jan 15	Jan 15				
16	Jan 16	Jan 16				
17	Jan 17	Jan 17				
18	Jan 18	Jan 18				
19	Jan 19	Jan 19				
20	Jan 20	Jan 20				
21	Jan 21	Jan 21				
22	Jan 22	Jan 22				
23	Jan 23	Jan 23				
24	Jan 24	Jan 24				
25	Jan 25	Jan 25				
26	Jan 26	Jan 26				
27	Jan 27	Jan 27				
28	Jan 28	Jan 28				
29	Jan 29	Jan 29				
30	Jan 30	Jan 30				
31	Jan 31	Jan 31				
32	Feb 1	Feb 1				
33	Feb 2	Feb 2				
34	Feb 3	Feb 3				
35	Feb 4	Feb 4				
36	Feb 5	Feb 5				
37	Feb 6	Feb 6				
38	Feb 7	Feb 7				
39	Feb 8	Feb 8				
40	Feb 9	Feb 9				
41	Feb 10	Feb 10				
42	Feb 11	Feb 11				
43	Feb 12	Feb 12				
44	Feb 13	Feb 13				
45	Feb 14	Feb 14				
46	Feb 15	Feb 15				
47	Feb 16	Feb 16				
48	Feb 17	Feb 17				
49	Feb 18	Feb 18				
50	Feb 19	Feb 19				
51	Feb 20	Feb 20				
52	Feb 21	Feb 21				
53	Feb 22	Feb 22				
54	Feb 23	Feb 23				
55	Feb 24	Feb 24				
56	Feb 25	Feb 25				
57	Feb 26	Feb 26				
58	Feb 27	Feb 27				
59	Feb 28	Feb 28				
60	Feb 29	Feb 29				
61	Mar 1	Mar 1				
62	Mar 2	Mar 2				
63	Mar 3	Mar 3				
64	Mar 4	Mar 4				
65	Mar 5	Mar 5				
66	Mar 6	Mar 6				
67	Mar 7	Mar 7				
68	Mar 8	Mar 8				
69	Mar 9	Mar 9				
70	Mar 10	Mar 10				
71	Mar 11	Mar 11				
72	Mar 12	Mar 12				
73	Mar 13	Mar 13				
74	Mar 14	Mar 14				
75	Mar 15	Mar 15				
76	Mar 16	Mar 16				
77	Mar 17	Mar 17				
78	Mar 18	Mar 18				
79	Mar 19	Mar 19				
80	Mar 20	Mar 20				
81	Mar 21	Mar 21				
82	Mar 22	Mar 22				
83	Mar 23	Mar 23				
84	Mar 24	Mar 24				
85	Mar 25	Mar 25				
86	Mar 26	Mar 26				
87	Mar 27	Mar 27				
88	Mar 28	Mar 28				
89	Mar 29	Mar 29				
90	Mar 30	Mar 30				
91	Mar 31	Mar 31				
92	Apr 1	Apr 1				
93	Apr 2	Apr 2				
94	Apr 3	Apr 3				
95	Apr 4	Apr 4				
96	Apr 5	Apr 5				
97	Apr 6	Apr 6				
98	Apr 7	Apr 7				
99	Apr 8	Apr 8				
100	Apr 9	Apr 9				
101	Apr 10	Apr 10				
102	Apr 11	Apr 11				
103	Apr 12	Apr 12				
104	Apr 13	Apr 13				
105	Apr 14	Apr 14				
106	Apr 15	Apr 15				
107	Apr 16	Apr 16				
108	Apr 17	Apr 17				
109	Apr 18	Apr 18				
110	Apr 19	Apr 19				
111	Apr 20	Apr 20				
112	Apr 21	Apr 21				
113	Apr 22	Apr 22				
114	Apr 23	Apr 23				
115	Apr 24	Apr 24				
116	Apr 25	Apr 25				
117	Apr 26	Apr 26				
118	Apr 27	Apr 27				
119	Apr 28	Apr 28				
120	Apr 29	Apr 29				
121	Apr 30	Apr 30				
122	May 1	May 1				
123	May 2	May 2				
124	May 3	May 3				
125	May 4	May 4				
126	May 5	May 5				
127	May 6	May 6				
128	May 7	May 7				
129	May 8	May 8				
130	May 9	May 9				
131	May 10	May 10				
132	May 11	May 11				
133	May 12	May 12				
134	May 13	May 13				
135	May 14	May 14				
136	May 15	May 15				
137	May 16	May 16				
138	May 17	May 17				
139	May 18	May 18				
140	May 19	May 19				
141	May 20	May 20				
142	May 21	May 21				
143	May 22	May 22				
144	May 23	May 23				
145	May 24	May 24				
146	May 25	May 25				
147	May 26	May 26				
148	May 27	May 27				
149	May 28	May 28				
150	May 29	May 29				
151	May 30	May 30				
152	May 31	May 31				
153	Jun 1	Jun 1				
154	Jun 2	Jun 2				
155	Jun 3	Jun 3				
156	Jun 4	Jun 4				
157	Jun 5	Jun 5				
158	Jun 6	Jun 6				
159	Jun 7	Jun 7				
160	Jun 8	Jun 8				
161	Jun 9	Jun 9				
162	Jun 10	Jun 10				
163	Jun 11	Jun 11				
164	Jun 12	Jun 12				
165	Jun 13	Jun 13				
166	Jun 14	Jun 14				
167	Jun 15	Jun 15				
168	Jun 16	Jun 16				
169	Jun 17	Jun 17				
170	Jun 18	Jun 18				
171	Jun 19	Jun 19				
172	Jun 20	Jun 20				
173	Jun 21	Jun 21				
174	Jun 22	Jun 22				
175	Jun 23	Jun 23				
176	Jun 24	Jun 24				
177	Jun 25	Jun 25				
178	Jun 26	Jun 26				
179	Jun 27	Jun 27				
180	Jun 28	Jun 28				
181	Jun 29	Jun 29				
182	Jun 30	Jun 30				
183	Jul 1	Jul 1				
184	Jul 2	Jul 2				
185	Jul 3	Jul 3				
186	Jul 4	Jul 4				
187	Jul 5	Jul 5				
188	Jul 6	Jul 6				
189	Jul 7	Jul 7				
190	Jul 8	Jul 8				
191	Jul 9	Jul 9				
192	Jul 10	Jul 10				
193	Jul 11	Jul 11				
194	Jul 12	Jul 12				
195	Jul 13	Jul 13				
196	Jul 14	Jul 14				
197	Jul 15	Jul 15				
198	Jul 16	Jul 16				
199	Jul 17	Jul 17				
200	Jul 18	Jul 18				
201	Jul 19	Jul 19				
202	Jul 20	Jul 20				
203	Jul 21	Jul 21				
204	Jul 22	Jul 22				
205	Jul 23	Jul 23				
206	Jul 24	Jul 24				
207	Jul 25	Jul 25				
208	Jul 26	Jul 26				
209	Jul 27	Jul 27				
210	Jul 28	Jul 28				
211	Jul 29	Jul 29				
212	Jul 30	Jul 30				
213	Jul 31	Jul 31				
214	Aug 1	Aug 1				
215	Aug 2	Aug 2				
216	Aug 3	Aug 3				
217	Aug 4	Aug 4				
218	Aug 5	Aug 5				
219	Aug 6	Aug 6				
220	Aug 7	Aug 7				
221	Aug 8	Aug 8				
222	Aug 9	Aug 9				
223	Aug 10	Aug 10				
224	Aug 11	Aug 11				
225	Aug 12	Aug 12				
226	Aug 13	Aug 13				
227	Aug 14	Aug 14				
228	Aug 15	Aug 15				
229	Aug 16	Aug 16				
230	Aug 17	Aug 17				
231	Aug 18	Aug 18				
232	Aug 19	Aug 19				
233	Aug 20	Aug 20				
234	Aug 21	Aug 21				
235	Aug 22	Aug 22				
236	Aug 23	Aug 23				
237	Aug 24	Aug 24				
238	Aug 25	Aug 25				
239	Aug 26	Aug 26				
240	Aug 27	Aug 27				
241	Aug 28	Aug 28				
242	Aug 29	Aug 29				
243	Aug 30	Aug 30				
244	Aug 31	Aug 31				
245	Sep 1	Sep 1				
246	Sep 2	Sep 2				
247	Sep 3	Sep 3				
248	Sep 4	Sep 4				
249	Sep 5	Sep 5				
250	Sep 6	Sep 6				
251	Sep 7	Sep 7				
252	Sep 8	Sep 8				
253	Sep 9	Sep 9				
254	Sep 10	Sep 10				
255	Sep 11	Sep 11				
256	Sep 12	Sep 12				
257	Sep 13	Sep 13				
258	Sep 14	Sep 14				
259	Sep 15	Sep 15				
260	Sep 16	Sep 16				
261	Sep 17	Sep 17				
262	Sep 18	Sep 18				
263	Sep 19	Sep 19				
264	Sep 20	Sep 20				
265	Sep 21	Sep 21				
266	Sep 22	Sep 22				
267	Sep 23	Sep 23				
268	Sep 24	Sep 24				
269	Sep 25	Sep 25				
270	Sep 26	Sep 26				
271	Sep 27	Sep 27				
272	Sep 28	Sep 28				

TABLE XVIIIb

Table of Required Sample Sizes

Sample size required for detecting with probability $1-\alpha$ whether

- a) the average m of a new product exceeds that of a standard m_0
- b) the average m of a new product is less than that of a standard m_0
- c) the average of a specified product m_A exceeds the average of another specified product m_B .

The standard deviations are assumed to be known

$$a) \quad d = \frac{m - m_0}{\sigma}$$

$$b) \quad d = \frac{m_0 - m}{\sigma}$$

$$c) \quad d = \frac{m_A - m_B}{\sqrt{\sigma_A^2 + \sigma_B^2}}$$

$$\alpha = .01$$

$d \backslash 1-\beta$.50	.60	.70	.80	.90	.95	.99
.1	542	666	813	1004	1302	1578	2165
.2	136	167	204	251	326	395	542
.4	34	42	51	63	82	99	136
.6	16	19	23	28	37	44	61
.8	9	11	13	16	21	25	34
1.0	6	7	9	11	14	16	22
1.2	4	5	6	7	10	11	16
1.4	3	4	5	6	7	9	12
1.6	3	3	4	4	6	7	9
1.8	2	3	3	4	5	5	7
2.0	2	2	3	3	4	4	6
3.0	1	1	1	2	2	2	3

If we must estimate σ from our sample, and use Student's t , then we should add 3 to the tabulated values to obtain the approximate required sample size. (If we are comparing two product averages, add 2 to the tabulated values. For this case, we must have $\sigma_A = \sigma_B$).

Table XVIIIb (Continued)

$$\alpha = .05$$

$d \backslash 1-\beta$.50	.60	.70	.80	.90	.95	.99
.1	271	361	471	619	857	1083	1578
.2	68	91	118	155	215	271	395
.4	17	23	30	39	54	68	99
.6	8	11	14	18	24	31	44
.8	5	6	8	10	14	17	25
1.0	3	4	5	7	9	11	16
1.2	2	3	4	5	6	8	11
1.4	2	2	3	4	5	6	9
1.6	2	2	2	3	4	5	7
1.8	1	2	2	2	3	4	5
2.0	1	1	2	2	3	3	4
3.0	1	1	1	1	1	2	2

If we must estimate σ from our sample, and use Student's t , then we should add 2 to the tabulated values to obtain the approximate required sample size. (If we are comparing two product averages, add 1 to the tabulated values. For this case, we must have $\sigma_A = \sigma_B$).

TABLE XIX

Percentiles for $\varphi = \frac{\bar{X} - m_0}{w}$

n	$\varphi .95$	$\varphi .975$	$\varphi .99$	$\varphi .995$	$\varphi .999$	$\varphi .9995$
2 (1) 20						

Reproduced from Table A-8c(1), Dixon and Massey,
Second Edition, McGraw-Hill (1957).

Table

Date: _____

Year	Month	Day	Time	Place	Event	Remarks

Prepared by: _____

Checked by: _____

TABLE XX

Percentiles for $\varphi' = \frac{\bar{X}_A - \bar{X}_B}{1/2(w_A + w_B)}$

$n=n_A=n_B$	$\varphi'.95$	$\varphi'.975$	$\varphi'.99$	$\varphi'.995$	$\varphi'.999$	$\varphi'.9995$
2						
3						
⋮						
20						

Reproduced from Table A-8c(2), Dixon and Massey, Second Edition, McGraw-Hill (1957).

Table 1

Summary of the results of the experiments conducted on the effect of the concentration of the solution on the rate of reaction.

Concentration of solution (M)	Initial rate of reaction (mol/L.s)	Final rate of reaction (mol/L.s)	Average rate of reaction (mol/L.s)	Time taken for reaction to complete (s)	Volume of gas evolved (cm ³)	Temperature (°C)
0.1	0.001	0.002	0.0015	10	10	25
0.2	0.002	0.004	0.003	5	20	25
0.3	0.003	0.006	0.0045	3	30	25
0.4	0.004	0.008	0.006	2	40	25
0.5	0.005	0.010	0.0075	1	50	25

From the above table, it can be seen that the rate of reaction increases with the concentration of the solution.

Graph of rate of reaction vs. concentration of solution.

1

Critical values of L for the Link-Wallace Test

$$\alpha = .05$$

t = number of groups = number of ranges

n = number in group = number per range

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2	3.43	2.37	1.78	1.40	1.16	1.00	.87	.78	.70	.66	.63	.58	.50	.47	.44	.42	.40	.38	.36
3	1.91	1.44	1.13	.94	.80	.70	.62	.56	.51	.47	.43	.40	.38	.36	.33	.32	.30	.29	.27
4	1.63	1.25	1.01	.84	.72	.63	.57	.51	.47	.43	.40	.37	.35	.33	.31	.29	.28	.27	.25
5	1.53	1.19	.96	.81	.70	.61	.55	.50	.45	.42	.39	.36	.34	.32	.30	.29	.27	.26	.25
6	1.50	1.18	.95	.80	.69	.61	.55	.49	.45	.42	.39	.36	.34	.32	.30	.29	.27	.26	.25
7	1.49	1.17	.95	.80	.69	.61	.55	.50	.45	.42	.39	.36	.34	.32	.30	.29	.28	.26	.25
8	1.49	1.17	.96	.81	.70	.62	.55	.50	.46	.42	.39	.37	.35	.33	.31	.29	.28	.27	.25
9	1.50	1.18	.97	.82	.71	.62	.56	.51	.47	.43	.40	.37	.35	.33	.31	.30	.28	.27	.26
10	1.52	1.20	.98	.83	.72	.63	.57	.52	.47	.44	.41	.38	.35	.34	.32	.30	.29	.27	.26
11	1.54	1.21	.99	.84	.73	.64	.58	.52	.48	.44	.41	.38	.36	.34	.32	.31	.29	.28	.27
12	1.56	1.23	1.00	.85	.74	.65	.59	.53	.49	.45	.42	.39	.37	.35	.33	.31	.30	.28	.27
13	1.58	1.25	1.02	.86	.75	.66	.59	.54	.49	.46	.42	.40	.37	.35	.33	.32	.30	.29	.27
14	1.60	1.26	1.03	.87	.76	.67	.60	.55	.50	.46	.43	.40	.38	.36	.34	.32	.31	.29	.28
15	1.62	1.28	1.05	.89	.77	.68	.61	.56	.51	.47	.44	.41	.38	.36	.34	.33	.31	.30	.28
16	1.64	1.30	1.06	.90	.78	.69	.62	.56	.52	.48	.44	.41	.39	.37	.35	.33	.31	.30	.29
17	1.66	1.31	1.08	.91	.79	.70	.63	.57	.52	.48	.45	.42	.39	.37	.35	.33	.32	.30	.29
18	1.68	1.33	1.09	.92	.80	.71	.64	.58	.53	.49	.46	.43	.40	.38	.36	.34	.32	.31	.30
19	1.70	1.34	1.10	.93	.81	.72	.65	.59	.54	.50	.46	.43	.40	.38	.36	.34	.33	.31	.30
20	1.72	1.36	1.11	.95	.82	.73	.65	.59	.54	.50	.47	.44	.41	.39	.37	.35	.33	.32	.30

Table XXI (Continued)

 $\alpha = .01$

t = number of groups = number of ranges

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2	7.92	4.42	2.96	2.06	1.69	1.39	1.20	1.03	.91	.82	.75	.68	.63	.59	.55	.51	.48	.46	.43
3	3.14	2.14	1.57	1.25	1.04	.89	.78	.69	.62	.57	.52	.48	.45	.42	.39	.37	.35	.34	.32
4	2.47	1.74	1.33	1.08	.91	.78	.69	.62	.56	.51	.47	.44	.41	.38	.36	.34	.32	.31	.29
5	2.24	1.60	1.24	1.02	.86	.75	.66	.59	.54	.49	.46	.42	.40	.37	.35	.33	.31	.30	.29
6	2.14	1.55	1.21	.99	.85	.74	.65	.59	.53	.49	.45	.42	.39	.37	.35	.33	.31	.30	.28
7	2.10	1.53	1.21	.99	.84	.74	.65	.59	.53	.49	.45	.42	.40	.37	.35	.33	.32	.30	.29
8	2.08	1.52	1.21	.99	.85	.74	.66	.59	.54	.50	.46	.43	.40	.37	.35	.33	.32	.30	.29
9	2.09	1.53	1.22	1.00	.85	.75	.66	.60	.54	.50	.46	.43	.40	.38	.36	.34	.32	.31	.29
10	2.10	1.55	1.23	1.01	.86	.75	.67	.61	.55	.51	.47	.44	.41	.38	.36	.34	.33	.31	.30
11	2.11	1.56	1.24	1.02	.88	.77	.68	.61	.56	.51	.48	.44	.42	.39	.37	.35	.33	.32	.30
12	2.13	1.58	1.25	1.03	.89	.78	.69	.62	.57	.52	.48	.45	.42	.40	.37	.35	.34	.32	.31
13	2.15	1.60	1.27	1.05	.90	.79	.70	.63	.58	.53	.49	.46	.43	.40	.38	.36	.34	.33	.31
14	2.18	1.62	1.28	1.06	.91	.80	.71	.64	.58	.54	.50	.46	.43	.41	.39	.37	.35	.33	.32
15	2.20	1.64	1.30	1.08	.92	.81	.72	.65	.59	.54	.50	.47	.44	.41	.39	.37	.35	.34	.32
16	2.22	1.65	1.31	1.09	.93	.82	.73	.66	.60	.55	.51	.48	.45	.42	.40	.38	.36	.34	.32
17	2.24	1.67	1.33	1.11	.95	.83	.74	.67	.61	.56	.52	.48	.45	.43	.40	.38	.36	.34	.33
18	2.27	1.69	1.34	1.12	.96	.84	.75	.68	.62	.57	.53	.49	.46	.43	.41	.39	.37	.35	.33
19	2.30	1.71	1.36	1.14	.97	.85	.76	.68	.62	.57	.53	.50	.46	.44	.41	.39	.37	.35	.34
20	2.32	1.73	1.38	1.15	.98	.86	.77	.69	.63	.58	.54	.50	.47	.44	.42	.40	.38	.36	.34

n = number in group = number per range



TABLE XXII

Percentiles of $F' = \frac{w_A}{w_B}$

n_B		n_A								
		2	3	4	5	6	7	8	9	10
2	.005	.0078								
	.01	.0157								
	.025	.039								
	.05	.079								
3	.005									
	.01									
	.025									
	.05									
4	"									
5	"									
6	"									
7	"									
8	"									
9	"									
10	"									

Taken from Table A-8d, Dixon and Massey, Second Edition, (1957).

Tables for Computing Confidence Limits for σ

Degrees of Freedom ν	A .05	A .95	A .025	A .975	A .01	A .99	A .005	A .995
1	.5103	15.947	.4461	31.910	.3882	79.786	.3562	159.576
2	.5778	4.415	.5207	6.285	.4660	9.975	.4344	14.124
3	.6196	2.920	.5665	3.729	.5142	5.111	.4834	6.467
4	.6493	2.372	.5992	2.874	.5489	3.669	.5188	4.396
5	.6721	2.089	.6242	2.453	.5757	3.003	.5464	3.485
6	.6903	1.915	.6444	2.202	.5974	2.623	.5688	2.980
7	.7054	1.797	.6612	2.035	.6155	2.377	.5875	2.660
8	.7183	1.711	.6754	1.916	.6310	2.204	.6037	2.439
9	.7293	1.645	.6878	1.826	.6445	2.076	.6177	2.278
10	.7391	1.593	.6987	1.755	.6564	1.977	.6301	2.154
11	.7477	1.551	.7084	1.698	.6670	1.898	.6412	2.056
12	.7554	1.515	.7171	1.651	.6765	1.833	.6512	1.976
13	.7624	1.485	.7250	1.611	.6852	1.779	.6603	1.909
14	.7688	1.460	.7321	1.577	.6931	1.733	.6686	1.854
15	.7747	1.437	.7387	1.548	.7004	1.694	.6762	1.806
20	.7979	1.358	.7650	1.444	.7297	1.556	.7071	1.640
25	.8149	1.308	.7843	1.380	.7511	1.473	.7299	1.542
30	.8279	1.274	.7991	1.337	.7678	1.416	.7477	1.475
40	.8470	1.228	.8210	1.279	.7925	1.343	.7740	1.390
50	.8606	1.199	.8367	1.243	.8103	1.297	.7931	1.337
60	.8710	1.179	.8487	1.217	.8239	1.265	.8078	1.299
70	.8793	1.163	.8583	1.198	.8349	1.241	.8196	1.272
80	.8861	1.151	.8662	1.183	.8439	1.222	.8293	1.250
90	.8919	1.141	.8728	1.171	.8515	1.207	.8376	1.233
100	.8968	1.133	.8785	1.161	.8581	1.195	.8446	1.219

For large degrees of freedom, the following approximate formula may be used

$$A_p = \sqrt{2\nu/(z_p + \sqrt{2\nu-1})^2}$$

U. S. DEPARTMENT OF COMMERCE

Sinclair Weeks, *Secretary*

NATIONAL BUREAU OF STANDARDS

A. V. Astin, *Director*



THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards at its headquarters in Washington, D. C., and its major field laboratories in Boulder, Colorado, is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant reports and publications, appears on the inside front cover of this report.

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Electricity and Electronics. Resistance and Reactance. Electron Tubes. Electrical Instruments. Magnetic Measurements. Dielectrics. Engineering Electronics. Electronic Instrumentation. Electrochemistry.

Optics and Metrology. Photometry and Colorimetry. Optical Instruments. Photographic Technology. Length. Engineering Metrology.

Heat and Power. Temperature Physics. Thermodynamics. Cryogenic Physics. Rheology and Lubrication. Engine Fuels.

Atomic and Radiation Physics. Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics. Nuclear Physics. Radioactivity. X-rays. Betatron. Nucleonic Instrumentation. Radiological Equipment. AEC Radiation Instruments.

Chemistry. Organic Coatings. Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Gas Chemistry. Physical Chemistry. Thermochemistry. Spectrochemistry. Pure Substances.

Mechanics. Sound. Mechanical Instruments. Fluid Mechanics. Engineering Mechanics. Mass and Scale. Capacity, Density, and Fluid Meters. Combustion Controls.

Organic and Fibrous Materials. Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Organic Plastics. Dental Research.

Metallurgy. Thermal Metallurgy. Chemical Metallurgy. Mechanical Metallurgy. Corrosion. Metal Physics.

Mineral Products. Engineering Ceramics. Glass. Refractories. Enameled Metals. Concreting Materials. Constitution and Microstructure.

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• Office of Basic Instrumentation

• Office of Weights and Measures

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Radio Propagation Physics. Upper Atmosphere Research. Ionospheric Research. Regular Propagation Services. Sun-Earth Relationships.

Radio Propagation Engineering. Data Reduction Instrumentation. Modulation Systems. Navigation Systems. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Radio Systems Application Engineering.

Radio Standards. Radio Frequencies. Microwave Frequencies. High Frequency Electrical Standards. Radio Broadcast Service. High Frequency Impedance Standards. Calibration Center. Microwave Physics. Microwave Circuit Standards.

